

**Amendments to the Claims**

We enclose herewith an amended set of claims and ask that these be substituted for the claims currently on file. The amended claims are based on the claims as filed, but amended to further distinguish from the cited art.

1. (Previously Amended) A method of providing frequency reuse in a communication system, the method including:
  - receiving a plurality of transmission signals with a plurality of receiver elements wherein said plurality of transmission signals are transmitted by a transmitter having a plurality of transmitting elements, the receiver elements capable of providing a plurality of received signals having known ratios of co-channel interference,
  - providing the received signals with algebraically unique ratios of co-channel interference, and
  - separating at least one desired signal from the received signals.
2. (Original) The method of claim 1 wherein the step of providing the received signals with algebraically unique ratios of co-channel interference includes shaping at least one spatial gain distribution of at least one of the transmitted signals.
3. (Original) The method of claim 1 wherein the step of providing the received signals with algebraically unique ratios of co-channel interference includes shaping at least one spatial gain distribution of at least one of the received signals.
4. (Original) The method of claim 1 wherein the step of providing the received signals with algebraically unique ratios of co-channel interference includes at least one of a set of methods including aperture synthesis, beam steering, lensing, and interferometric combining.
5. (Original) The method of claim 1 wherein the step of providing the received signals

with algebraically unique ratios of co-channel interference is performed in response to a feedback signal from at least one receiver.

6. (Original) The method of claim 1 wherein the receiver elements are spatially separated array elements.
7. (Previously Amended) The method of claim 1 wherein the receiver elements include more than two polarization elements and the co-channel interference includes cross polarization.
8. (Previously Amended) The method of claim 1 wherein the step of providing the received signals with algebraically unique ratios of co-channel interference includes an optimization process wherein the optimization process controls the step of providing the received signals with algebraically unique ratios of co-channel interference.
9. (Previously Amended) The method of claim 8 wherein the ratios of co-channel interference result from spatial gain distributions of the received signals.
10. (Original) The method of claim 9 wherein the spatial gain distribution includes at least one minima in a predetermined spatial region.
11. (Original) The method of claim 9 wherein the spatial gain distribution includes at least one spatial region having at least one predetermined ratio of signal levels.
12. (Original) The method of claim 9 wherein the spatial gain distribution is controlled by directionality of the receivers.
13. (Original) The method of claim 9 wherein the spatial gain distribution is created by an overlap of at least two transmitted signals.

14. (Original) The method of claim 1 wherein the ratios of co-channel interference provide weights to a cancellation step that is included in the step of providing separation of the transmitted signals from the received signals.
15. (Original) The method of claim 14 wherein the weights have complex values.
16. (Original) The method of claim 14 wherein at least one of the weights includes a delay element.
17. (Original) The method of claim 14 wherein the weights are frequency-dependent weights, the transmission signals having diverse frequency characteristics.
18. (Original) The method of claim 14 wherein the weights are frequency-dependent weights and the transmission signals have a plurality of signal frequencies.
19. (Previously Amended) A method of bandwidth-efficient communications that achieves frequency reuse, the method including:
- transmitting a plurality of transmission signals from a transmitter having a plurality of transmitting elements wherein the plurality of transmission signals have at least one common frequency channel,
  - receiving the plurality of transmitted signals with a plurality of receiver elements for providing a plurality of received signals, the received signals having known ratios of co-channel interference,
  - providing the received signals with algebraically unique ratios of co-channel interference, and
  - separating at least one desired signal from the received signals.
20. (Previously Amended) A method of array processing that enables simultaneous frequency use of a plurality of transmitted signals from a transmitter having a plurality of transmitter elements, the method including steps of:
- determining a plurality of ratios of co-channel interference occurring between the

transmitted signals received at each of a plurality of receivers,

- receiving the transmitted signals at the receivers, the receivers capable of being responsive to the received transmitted signals for providing a plurality of received signals, the received signals having known ratios of co-channel interference,
- providing the received signals with algebraically unique ratios of co-channel interference, and
- separating the transmitted signals from the received signals.

21. (Cancelled) A method of bandwidth-efficient communications that achieves frequency reuse, the method including steps of:

- providing transmission by a transmitter having a plurality of transmitter elements of a plurality of transmission signals having at least one common frequency channel,
- providing determination of a plurality of ratios of co-channel interference occurring between the transmitted signals received by a plurality of receivers,
- receiving the transmitted signals with the receivers, the receivers capable of being responsive to the received transmitted signals for providing a plurality of received signals having known ratios of co-channel interference,
- providing the received signals with algebraically unique ratios of co-channel interference, and
- providing separation of the transmitted signals from the received signals.

22. (Amended) A method of optimizing separation of a plurality of transmitted signals received by a plurality of receiver elements coupled to a cancellation circuit, the method including steps of:

- receiving a plurality of transmission signals transmitted in at least one common frequency channel by at least one transmitter having a plurality of transmitter elements, the transmission signals being received by said plurality of receiver elements for providing a plurality of received signals with a plurality of algebraically unique proportions of co-channel interference, at least one of the received signals having co-channel interference,

- providing at least one determination of signal quality for at least one of a plurality of separated signals output by the cancellation circuit,
  - providing at least one feedback signal to at least one transmitter that generates the transmission signals, and
  - adjusting at least one transmission parameter to provide adjustment to the algebraically unique proportions of co-channel interference of at least one received signal, the adjustment of the at least one transmission parameter being related to the value of the feedback signal.
23. (Amended) A method of separating a plurality of received transmission signals transmitted by at least one transmitter having a plurality of transmitter elements adapted to transmit a plurality of signals having co-channel interference, the received transmission signals having known ratios of co-channel interference, the method including:
- receiving the transmission signals with a plurality of receivers capable of providing a plurality of received signals having ~~known~~ algebraically unique ratios of co-channel interference,
  - providing weights to a cancellation circuit based on the ratios of co-channel interference, and
  - coupling the received signals into the cancellation circuit, the cancellation circuit being capable of separating the received transmission signals.
24. (Withdrawn) A method of determining spatial gain distributions of a plurality of signals received by a plurality of receivers, the method including:
- transmitting at least one known reference signal,
  - measuring the at least one reference signal received by each of the receivers for producing a plurality of measurements, and
  - determining ratios of co-channel interference from the measurements.
25. (Amended) In an electromagnetic-wave communication system, a signal canceller capable of separating one or more transmission signals from a plurality of interfering

transmission signals transmitted by at least one transmitter having a plurality of transmitter elements and adapted to transmit a plurality of signals having co-channel interference, the plurality of signals being received by a receiver having a plurality of receiver elements, the signal canceller adapted to be coupled to the receiver, the signal canceller including:

a frequency filter coupled to the receiver capable of receiving a plurality of the received transmission signals, each of the received signals having an algebraically unique combination of the transmission signals and each of the transmission signals having distributed frequency characteristics, the frequency filter capable of separating each of the received signals into a plurality of received-signal frequency components;

a plurality of weighting elements coupled to the frequency filter, the weighting elements capable of providing a weight to each of the received-signal frequency components to provide a plurality of weighted received-signal frequency components; and

a signal combiner capable of summing the weighted received-signal frequency components to separate the received transmission signals.

26. (Amended) In an electromagnetic-wave communication system, a signal canceller capable of separating one or more transmission signals from a plurality of interfering transmission signals transmitted by at least one transmitter having a plurality of transmitter elements adapted to generate a plurality of signals having co-channel interference and received by a receiver having a plurality of receiver elements, the signal canceller including:

- a plurality of weighting elements coupled to the receiver capable of receiving a plurality of receive signals from the receiver, each of the receive signals having an algebraically unique combination of the transmission signals, the weighting elements capable of providing at least one weight to each of the receive signals to provide a plurality of weighted receive signals and
- a signal combiner capable of summing the weighted receive signals to separate the interfering transmission signals.

27. (Amended) In an electromagnetic-wave communication system capable of using interference cancellation to achieve frequency reuse, a receiver capable of separating a plurality of received transmission signals transmitted by at least one transmitter having a plurality of transmitter elements adapted to generate a plurality of transmission signals having co-channel interference, the receiver including:

- a plurality of receiver elements capable of sampling the transmission signals, the receiver elements capable of being responsive to the transmission signals for generating a plurality of receive signals wherein each of the receive signals includes an algebraically unique combination of the transmission signals and
- a canceller coupled to the receiver elements capable of separating one or more of the received transmission signals.

28. (Original) The receiver of claim 27 wherein the plurality of receiver elements is an antenna array that includes a plurality of antenna-array beam processors, the receive signals being output from each of the processors.

29. (Amended) In an electromagnetic-wave communication system, a receiver capable of receiving a plurality of algebraically unique proportions of more than two differently polarized transmission signals transmitted by at least one transmitter adapted to generate a plurality of transmission signals having co-channel interference, the receiver adapted to separate at least one of the received transmission signals, the receiver including:

a plurality of polarized receiver elements capable of having different polarizations, each of the receiver elements capable of having a different responsiveness to the differently polarized transmission signals for generating a plurality of receive signals wherein each of the receive signals includes an algebraically unique combination of the transmission signals, and

a canceller coupled to the receiver elements capable of receiving the receive signals and separating one or more of the received transmission signals therefrom.

**Remarks: Examination Report**

It is submitted that with the amended claims herein, the objections raised against the claims are overcome.

***1. Section 1 of the Examination Report***

The rejections of Claims 1-21 have been withdrawn.

***2. Section 2 of the Examination Report***

Arguments with respect to Claim 22 were considered to be unpersuasive. In particular, the Examiner states that the parallel filters 41a-41c in Laasko's receiver constitutes multiple receivers that provide a plurality of received signals.

***3. Section 3 of the Examination Report***

New grounds for rejection are presented for Claims 23 and 25-29.

***4. Section 4 of the Examination Report***

Claim rejections under 35 USC 102 are noted.

***5. Section 5 of the Examination Report***

Claim 22 was rejected under 35 USC 102(e) as being anticipated by Laasko (U.S. Pat. No. 5,898,740).

6. Applicant submits that the above-recited step of receiving a plurality of transmission signals transmitted in at least one common frequency channel by at least one transmitter having a plurality of transmitter elements, the transmission signals being



received by said plurality of receiver elements for providing a plurality of received signals with a plurality of algebraically unique proportions of co-channel interference, and the step of adjusting at least one transmission parameter to provide adjustment to the algebraically unique proportions of co-channel interference of at least one received signal, the adjustment of the at least one transmission parameter being related to the value of the feedback signal, such as recited in the amended independent claim 22 clearly presents a novel method that the prior-art references neither describe nor anticipate. Thus, the amended independent claim 22 should be considered patentable under 35 U.S.C. 102.

7. Specifically, the claimed invention enables point-to-point communications between antenna arrays. In particular, the claimed invention recites a multi-element receiver in communication with a multi-element transmitter that **deliberately generates interference** between same-frequency channels for communication. The ability to separate the interfering signals at the receiver depends on said plurality of receiver elements providing the received signals with **algebraically unique proportions of co-channel interference**. Unlike Laasko's system, the claimed invention employs a multi-element transmitter to transmit interfering signals, thus providing substantial improvements in capacity and bandwidth efficiency.
8. No other prior-art reference discloses a multi-element receiver adapted to separate co-channel interference transmitted by a multi-element transmitter. No other prior-art reference describes a communication method between two antenna arrays that enables the simultaneous use of multiple same-frequency communication channels. Consequently, no other prior-art reference discloses the combination of deliberately generating interfering transmissions and then providing the received signals with **algebraically unique proportions of co-channel interference**.
9. None of the prior-art references teach to receive a plurality of transmission signals transmitted in at least one common frequency channel by a transmitter having a plurality of transmitter elements. None of the prior-art references teach

**to reuse frequency channels for communications between a transmitter having a plurality of transmitter elements and a receiver having a plurality of receiver elements.**

Laasko shows a method and apparatus for compensating for multiple-access interference in a CDMA system. Although each user shares the same frequency channel with other users, user signals are separable via orthogonal coding (col. 1, lines 34-49). Multipath, or other channel distortions, cause multiple-access interference between user codes (col. 1, lines 50-65). Laasko teaches to mitigate this multiple-access interference via interference cancellation. Laasko fails to teach any method of processing interfering signals transmitted from a **transmitter array** via interference cancellation at a **receiver array**. Thus, Laasko teaches no increase in throughput beyond what can be achieved by orthogonal CDMA (col. 3, lines 19-23). Laasko merely teaches to compensate for multipath effects that would otherwise reduce the capacity of a CDMA system. Consequently, Laasko fails to show any method or apparatus that is even capable of providing frequency reuse (i.e., sharing of multiple same-frequency channels by a plurality of signals providing predetermined amounts of co-channel interference).

It will be appreciated therefore that the schema described by the cited art is not the same as that claimed by the present invention. The present claims are therefore novel.

**10. The claimed invention is also non-obvious, making the claims patentable under U.S.C. 103.**

11. As detailed above, the cited art describes a different type of communication protocol to that claimed by the present invention. Although different to the present invention, such protocols have use, as is evidenced by the teaching of the prior art. Such use is served by the SDMA protocol, and there is no teaching in the prior art to change the type of communication protocol provided so as to resemble or reflect that of the present invention. As there is no motivation to change, no teaching to change, and no

description of how any change may be made to produce the protocol recited in the claimed invention, it is submitted that the presently claimed invention is also non-obvious, making the claims patentable under U.S.C. 103.

***12. Section 6 of the Examination Report***

Claim 23 was rejected under 35 USC 103(a) as being unpatentable over Martin (U.S. Pat. No. 5,875,216) in view of Hageltorn (U.S. Pat. No. 6,006,117). Although Martin does not disclose that the transmitters have a plurality of transmitter elements, Hageltorn discloses a transmitter with a plurality of elements.

***13. Section 7 of the Examination Report***

Claim 25 was rejected under 35 USC 103(a) as being unpatentable over Barrat (U.S. Pat. No. 5,592,490) in view of Hageltorn (U.S. Pat. No. 6,006,117). Although Barrat does not disclose that the transmitters have a plurality of transmitter elements, Hageltorn discloses a transmitter with a plurality of elements.

***14. Section 8 of the Examination Report***

Claims 26-28 were rejected under 35 USC 103(a) as being unpatentable over Roy (U.S. Pat. No. 5,515,378) in view of Hageltorn (U.S. Pat. No. 6,006,117). Although Roy does not disclose that the transmitters have a plurality of transmitter elements, Hageltorn discloses a transmitter with a plurality of elements.

15. Applicant submits that the above-recited method of separating a plurality of received transmission signals transmitted by at least one transmitter having a **plurality of transmitter elements adapted to transmit a plurality of signals having co-channel interference**, such as recited in the amended independent Claim 23 clearly present a novel method that is not taught nor anticipated by the prior art. Thus, the amended independent Claim 23 should be considered patentable under 35 U.S.C. 103.

16. Applicant submits that the recited apparatus in the amended independent Claims 25-27 (and consequently, in the dependent claim 28) adapted to separate a plurality of received transmission signals transmitted by at least one transmitter having a plurality of transmitter elements **adapted to generate a plurality of transmission signals having co-channel interference** clearly present novel structure and functionality that is not taught nor anticipated by the prior art. Thus, the amended independent Claims 25-27 (and consequently, the dependent claim 28) should be considered patentable under 35 U.S.C. 103.
17. In particular, the **deliberate** transmission of a plurality of **interfering** signals by a plurality of transmitters that is intended for a remote receiver should be considered non-obvious because it is taught against by the prior art. The prior art teaches to avoid creating such interference because it is detrimental to the performance of receivers. Where the prior art discloses transmission by multiple antennas, the intent is to provide non-simultaneous use of the antennas (such as disclosed in Hageltorn), to provide for redundant transmission for achieving diversity gains, or to provide for beam forming to transmit to spatially separated receivers (such as disclosed in Martin). The present invention not only discloses a receiver interference cancellation technique to separate such interfering signals, it demonstrates that such interfering transmissions are desirable for significantly increasing throughput and capacity compared to prior-art teachings.
18. None of the prior-art references teach to receive a plurality of transmission signals transmitted in at least one common frequency channel by a transmitter **having a plurality of transmitter elements. Accordingly, none of the prior-art references achieve the increased capacity of the present invention.**

In Hageltorn, one antenna is used in standby mode and the other antenna is used during calls. Even if the two antennas were used simultaneously, only diversity gains (rather than capacity gains) would be realized at the receiver. In the case of diversity, different

reflections of the same transmitted signal are combined to mitigate the effects of fading. Thus, the prior-art technique of transmitting the same signal from a plurality of antennas improves diversity. The prior art fails to teach of any benefit if **different** signals are transmitted from multiple antennas, thus resulting in co-channel interference.

Alternatively, the present invention transmits different (and thus, interfering) signals from a plurality of transmitter elements. The plurality of receivers enables generation of a plurality of received signals having algebraically unique ratios of co-channel interference, thus enabling separation of the received signals. This results in significant capacity gain.

**19. The Novel Physical Feature of the Claims Provide New and Unexpected Results and Hence Should Be Considered Non-obvious, Making the Claims Patentable Under 35 U.S.C. 103.**

**20. The prior art teaches against the present invention.**

Conventional information theory teaches to avoid transmitting interfering signals. Although beam-forming techniques are well known in the prior art for providing frequency reuse, such prior-art systems cannot employ beam forming for communications between a transmitter array and a receiver array. Rather, prior-art beam-forming systems typically employ an antenna array base station and a plurality of spatially separated single-antenna mobile terminals. Since prior-art beam-forming techniques require substantial spatial separation (on the order of a beam width) between receivers, the transmission of interfering signals (such as claimed in the present invention) provides interference in the received signals that the prior-art is unable to remove.

**21. The present invention provides new and unusual results**

By providing a transmitter having a plurality of transmitter elements and a receiver having a plurality of receiver elements, and providing the receiver with the means to

separate received co-channel interference, the present invention enables the unusual ability to increase the information throughput in a point-to-point link via frequency reuse. No other prior-art reference discloses a multi-element receiver adapted to separate co-channel interference transmitted by a multi-element transmitter. No other prior-art reference describes a communication method between two antenna arrays that enables the simultaneous use of multiple same-frequency communication channels.

**22. There is no teaching in the prior art to apply the multiple transmit antennas described in Hageltorn in such a way as to derive the function and benefits of the present invention.**

23. As detailed above, the cited art describes a different type of transmission protocol to that claimed by the present invention. Although different to the present invention, such protocols have use, as is evidenced by the teaching of the prior art. Such use is served by the separate standby mode and call mode antennas described in Hageltorn, and there is no teaching in the prior art to change the type of communication protocol provided so as to resemble or reflect that of the present invention. As there is no motivation to change, no teaching to change, and no description of how any change may be made to produce the protocol recited in the claimed invention, it is submitted that the presently claimed invention is also non-obvious, making the claims patentable under U.S.C. 103.

***24. Section 9 of the Examination Report***

Claim 29 was rejected under 35 USC 103(a) as being unpatentable over Roy (U.S. Pat. No. 5,515,378) in view of DiFonzo (U.S. Pat. No. 3,963,990). Although Roy does not disclose that the transmission signals are differently polarized or that the receiver elements are polarized, DiFonzo discloses a receiver which has a plurality of polarized receiver elements having different polarizations.

25. Applicant submits that the included in the above-recited apparatus in the amended independent Claim 29, a receiver adapted to separate a plurality of received transmission signals transmitted by at least one transmitter having a **plurality of transmitter elements adapted to transmit a plurality of signals having co-channel interference** clearly presents novel structure that is not taught nor anticipated by the prior art. Thus, the amended independent Claim 29 should be considered patentable under 35 U.S.C. 103.
26. In particular, receiving transmissions of a plurality of **deliberately interfering** signals from a plurality of transmitters that is intended for a remote receiver should be considered non-obvious because it is taught against by the prior art. The prior art teaches to avoid creating such interference because it is detrimental to the performance of receivers.
27. **None of the prior-art references teach to generate deliberately interfering signals and provide for the reception of such signals. Accordingly, none of the prior-art references achieve the increased capacity of the present invention.**
- DiFonzo discloses an interference-reduction circuit for canceling cross-polarization interference resulting from channel distortions and antenna misalignment (col. 1, lines 21-32 and col. 3, lines 7-36). Consequently, the need to cancel more than two received polarized signals results from the propagation channel rather than from separating transmissions that deliberately employ more than the two orthogonal polarizations. DiFonzo describes transmitting two orthogonal polarizations (col. 1, lines 14-16) to double bandwidth rather than transmitting mutually interfering (i.e., non-orthogonal) polarizations and providing an appropriate cancellation system at the receiver to further increase bandwidth.
28. **The Novel Physical Feature of the Claims Provide New and Unexpected Results and Hence Should Be Considered Non-obvious, Making the Claims Patentable Under 35 U.S.C. 103.**

**29. The prior art teaches against the present invention.**

Conventional information theory teaches to avoid transmitting interfering signals. For example, DiFonzo discloses an interference-reduction circuit for solving the problem of polarization cross-coupling, which results from antenna misalignment and propagation effects. The prior art fails to utilize polarization cross-coupling as a desirable feature for enabling increased bandwidth efficiency.

**30. The present invention provides new and unusual results**

By deliberately providing the transmitted polarized signals with cross-coupling interference, and providing the receiver with the means to separate received co-channel interference, the present invention enables the unusual ability to increase the information throughput in a point-to-point link via frequency reuse. No other prior-art reference discloses a receiver adapted to separate co-channel interference transmitted by a transmitter that multiplexes more than two polarized signals by deliberately causing cross-coupling interference.

**31. There is no teaching in the prior art to apply the system described in DiFonzo in such a way as to promote the transmission of cross coupled interference.**

32. As detailed above, the cited art describes a different type of transmission system to that claimed by the present invention. Although different to the present invention, such systems have use, as is evidenced by the teaching of the prior art. Such use is served by the use of two orthogonally polarized transmissions described in DiFonzo, and there is no teaching in the prior art to change the type of communication protocol provided so as to resemble or reflect that of the present invention. As there is no motivation to change, no teaching to change, and no description of how any change may be made to produce the protocol recited in the claimed invention, it is submitted



that the presently claimed invention is also non-obvious, making the claims patentable under U.S.C. 103.

**The Cited but Non-Applied References**

33. The prior-art references made of record and not relied upon have been studied, but are submitted to be less relevant than the relied-upon references.

Very respectfully,



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